

# PECTORALIS MAJOR TENDON REPAIR POST SURGICAL REHABILITATION

Robert C. Manske, PT, DPT, SCS, ATC<sup>a</sup>

Dan Prohaska, MD<sup>b</sup>

## ABSTRACT

Pectoralis major tendon rupture is a rare shoulder injury, most commonly seen in weight lifters. This injury is being seen more regularly due to the increased emphasis on healthy lifestyles. Surgical repair of the pectoralis major tendon rupture has been shown to provide superior outcomes regarding strength return. Thus it appears that surgical repair is the treatment of choice for those wishing to return to competitive or recreational athletic activity. This article describes the history and physical examination process for the athlete with pectoralis tendon major rupture. Surgical vs conservative treatment will be discussed. This manuscript provides post surgical treatment guidelines that can be followed after surgical repair of the pectoralis tendon rupture.

**Key Words:** weightlifting, pectoralis major, rupture

## CORRESPONDENCE:

Robert C. Manske, PT, DPT, SCS, ATC  
Wichita State University  
Department of Physical Therapy  
1845 North Fairmount  
Wichita, KS 67260-0043  
Office: 316-978-3702  
Fax: 316-978-3025  
eMail: Robert.manske@wichita.edu

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<sup>a</sup> Wichita State University  
Department of Physical Therapy  
Via Christa Orthopedic and Sports Physical Therapy  
Wichita, Kansas

<sup>b</sup> Advanced Orthopedic Associates  
Wichita, Kansas

## INTRODUCTION

Pattissier<sup>1</sup> initially described rupture of the pectoralis major muscle in 1822. Although, initially described as a rare injury, the numbers of athletic patients requiring surgical repair of the ruptured pectoralis tendon is increasing. This injury can be devastating to the active athletic patient if treatment does not return full functional strength and range of motion of the injured upper extremity.<sup>2</sup> The objectives of this article are to describe the relevant anatomy of the pectoralis region and discuss evaluation, operative, and rehabilitative approaches to treatment of this potentially disabling upper extremity injury.

## Anatomy/Kinesiology

The pectoralis major muscle is a very powerful shoulder muscle during its function – that of shoulder adductor, internal rotator, and flexor of the humerus. Origins of the pectoralis major include the clavicle, sternum, ribs, and external oblique fascia<sup>3</sup> as well as cartilage of the first six ribs.<sup>4</sup> This large muscle, located on the anterior chest wall overlying the pectoralis minor, has both a sternal and a clavicular head. The clavicular portion of the pectoralis major originates on the lateral clavicle and upper sternum and inserts onto the inferior surface of the humerus at the crest of the greater tuberosity. The sternal head of the pectoralis major originates on the manubrial end of the sternum and inserts onto the lower humerus with the clavicular portion. The insertion of the pectoralis tendon onto the humerus occurs with the muscle twisting on itself so that the lowest fibers of the tendon insert at the highest location on the humerus.<sup>5,6</sup> Wolfe et al<sup>7</sup> have previously demonstrated that this attachment results in significant tension in the inferior portion of the pectoralis muscle and predisposes this portion to rupture when stretched and loaded. Wolfe and colleagues<sup>7</sup> measured excursion of individual pectoralis muscle fibers at seven different points along the origin by the use of fine wires connected to humeral insertion and to dial gauges. Inferior fibers of the pectoralis major muscle lengthened

disproportionately during the final 30 degrees of humeral extension. This attachment arrangement may result in partial tears being much more common than that of complete ruptures.

## Mechanism of Injury

Although pectoralis tendon ruptures are most commonly seen in weight lifting, ruptures have also been reported in many other sporting activities such as boxing, football, rodeo, water skiing, and wrestling.<sup>8-12</sup> These injuries tend to occur more commonly in patients during their second to fourth decade of life.<sup>2</sup> To date, this rupture is a totally male dominated athletic injury with not even a single case study report of injury to the female athletic population. The diagnosis of pectoralis tears is generally not elusive. Patients often give a history of doing a maximal lift or effort and feeling something in the shoulder giving or ripping; while the injury is often accompanied by an audible “snap” or “pop”.<sup>11-18</sup> Mild swelling and often ecchymosis<sup>2,8,14,18,19-23</sup> follows. Bruising can be seen over the anterior lateral chest wall or in the proximal arm.<sup>24</sup> Pain generally is not intense.<sup>24</sup>

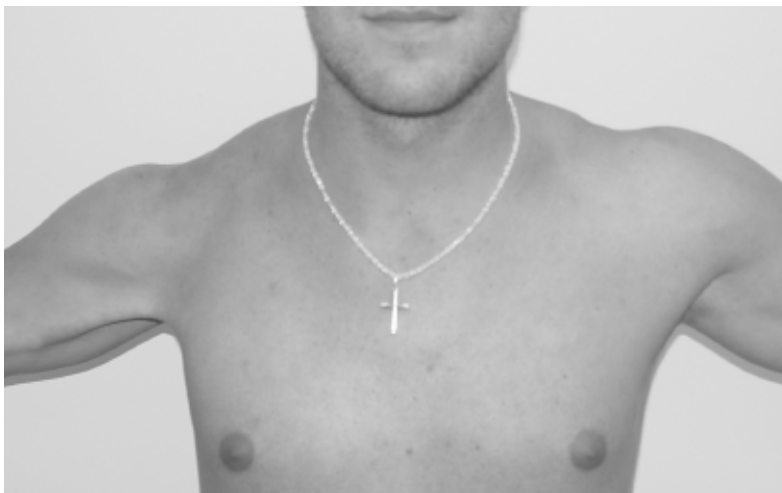


Figure 1. Loss of normal pectoralis contour.

Physical exam reveals a loss of the anterior axillary fold and normal pectoralis contour (*Figure 1*). Asking patients to press the hands together in a “prayer position” (*Figure 2*) eliciting an isometric contraction will reveal asymmetry to the chest wall. This asymmetry can be easily confirmed by looking for medial movement of the nipple on the chest wall.

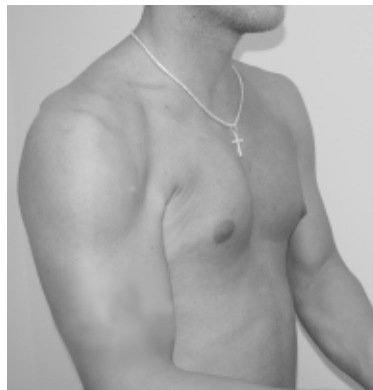
Often a distinct deformity or hollow exists where the pectoralis muscle will move medial. Loss of strength is particularly notable to internal rotation of the arm when tested at neutral.

Diagnostic testing may include plain radiographs which are usually not diagnostic, although reports of bony abnormalities have been noted.<sup>2,21,22,25,26</sup> Magnetic resonance imaging (MRI) can be helpful and is becoming the imaging method of choice and can be helpful where a partial tear is suspected.<sup>27-29</sup> The partial tear may be difficult to evaluate. An MRI can be helpful in assessing location and severity of the tear.<sup>30</sup> The tendon fibers from the clav-

icular head may be intact and be interpreted as an intact tendon. This finding must be interpreted carefully as partial tears which do not include the clavicular head have significant morbidity and should be given consideration for operative treatment. If edema is present, careful scrutiny should be given to the tendon to assess for pathology.



A) Anterior View



B) Lateral view

Figure 2. Asymmetry seen with isometric contraction of pectoralis major A) anterior view, B) lateral view.

### CONSERVATIVE VS. SURGICAL TREATMENT

Historically, non-operative treatment has been advocated for older or sedentary individuals or for those with incomplete tears.<sup>21</sup> Unfortunately, rarely does non-operative treatment result in return of normal strength.<sup>14,20,31</sup> Wolf et al<sup>7</sup> has reported up to a 26% loss of peak torque and a 39.9% work deficit in shoulder adduction in un-repaired ruptures. Furthermore, numerous studies have demonstrated that surgical treatment of complete pectoralis tendon ruptures has a defined advantage in regards to increased strength over that of non-operative treatment, especially in athletes.<sup>5,9,13,17-19,23,27,32-42</sup>

### SURGICAL TREATMENT

The authors preferred method of repair of the pectoralis major tendon is with the patient on the operative table in a beach chair position with the arm draped free. The incision is placed in the anterior axillary fold (Figure 3). A short incision of 5-8 cm is usually used in acute cases, or longer if the tendon tear is more chronic. This incision is very cosmetic and can be placed posterior enough in the axillary fold to allow the incision to be hidden when the arm is at the side. When done at this position, the resultant fine scar will often blend in and appear as a stretch mark which is met with favorable acceptance by the typical patient with this injury.

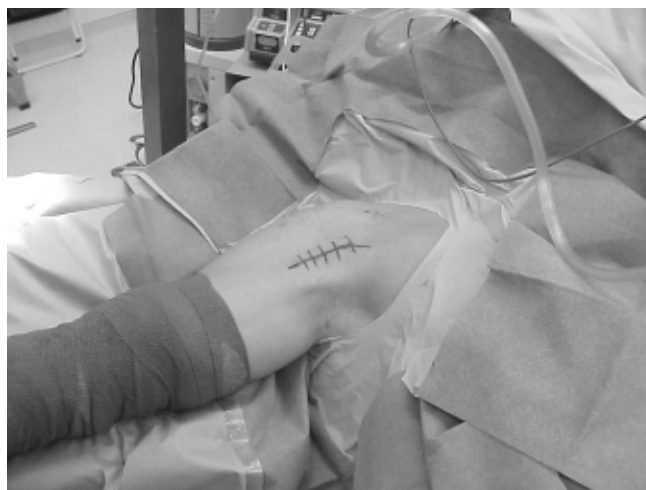


Figure 3. Incision line.

The surgical approach is begun by developing soft tissue planes and identifying the torn tendon end (Figure 4). If the tendon is identified after finding the deltopectoral interval and appears intact, the arm should be abducted and externally rotated. This maneuver will often identify a partial tear of the sternal head, which should be repaired.

More chronic cases will

require mobilization of the tendon. This mobilization of the tendon can be performed with careful dissection recognizing potential hazards posterior and medial to the pectoralis tendon.

The tendon can rupture from the attachment to bone or as a musculotendinous junction tear. If the tendon has ruptured proximal to the bony insertion, the tendon is repaired with permanent sutures, preferably a polyblend for strength to allow for mobilization.

If the tendon ruptures from the bony attachment, then the repair can be performed with bone tunnels and sutures, or by the authors' preference of using suture anchors. This technique will require pre-drilling bone tunnels for suture anchor placement (Figure 5). The suture anchor technique has some pitfalls as this bone is very hard and care has to be taken not to fracture a bioabsorbable anchor on insertion or twist off a metal anchor if

this is how it is inserted.

Preparation of the insertion site can be performed with a rongeur (a spring-loaded forceps with a sharp blade), or if concerned about the healing potential, the cortex can be further abraded with a burr. Three to four anchors are placed in a typical complete tear. Sutures are then passed using a grasping suture technique with one strand, such as the Modified Mason-Allen. The second strand is brought into the end of the tendon and

then out the anterior aspect 5-10 mm from the lateral edge. This technique allows for the suture to slide through the anchor and the tendon to pull the grasping arm down and allows the tendon to have full interface with the bone. This technique also places the suture knot on the anterior aspect of the tendon where the knot will not cause any irritation.

Before and after the tendon is repaired the range of motion of the shoulder is assessed while observing the repair site. Early repairs, less than three weeks, are often very mobile. This mobility allows for a more rapid return of shoulder motion post-operatively.

Once the repair is finished, (Figure 6) the wound is closed in layers with a dermal subcuticular closure for cosmesis. Subcuticular injection of local anesthetic is used. The arm is placed in a sling immobilizer, unless concern exists about abduction and then consideration is given to a simple sling.

## POST-OPERATIVE REHABILITATION

Because no studies have been published that discuss pectoralis major tendon repair strain properties, the amount of stress this tissue can tolerate prior to rupture or compromise in the post surgical patient is not fully understood. Therefore, post surgical rehabilitation soft tissue healing time frames following pectoralis tendon repair are based on clinical impression and empirical evidence in treating these athletes. Additionally, some general assumptions can be made based on previous literature related to soft tissue healing of other common tendon rupture repairs including the rotator cuff and Achilles tendons.<sup>43-52</sup>



Figure 4. Identifying pectoralis major.



Figure 5. Drilling tunnel for suture anchor placement.

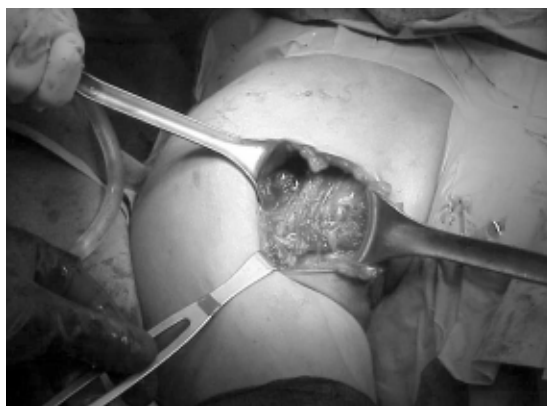


Figure 6. Completed pectoralis tendon repair.

Post-operative rehabilitation following pectoralis major tendon repair is dependent on several surgical considerations. Direct repairs of pectoralis major muscle to tendon is difficult because the ability to obtain a firm anchorage for suture in soft muscle tissue is limited.<sup>12</sup> For this reason, speculation is that direct repairs of muscle to tendon or those from tendon to tendon may require greater soft tissue time constraints. This repair may be so tenuous that some authors even suggest conservative treatment following a tear in the musculo-tendinous region.<sup>36,37</sup> Post surgical rehabilitation requires a balancing act of maintaining enough restriction of range of motion to allow adequate soft tissue healing, yet still allowing enough activity and motion to restore shoulder mobility, all the while gradually returning functional strength to allow a return of full unrestricted functional activities. In numerous instances these functional activities are to return the athlete to very high levels of strength since a large majority of these injuries occur in competitive or recreational weightlifters. Because damaging the healing tendon immediately following surgery is contraindicated, the patient's shoulder is generally placed in an immobilizer or a sling for the first 3-4 weeks, depending on the type of surgery required (Table 1).

As with most post-operative rehabilitation, the ultimate goals following pectoralis major repair include 1) maintaining structural integrity of the repaired soft tissues, 2) gradually restoring full functional range of motion, 3) restoring or enhancing full dynamic muscle control and stability, and 4) return of full unrestricted upper extremity activities including activities of daily living and recreation and sporting athletic endeavors. The ultimate goal is to return



the patient to their preferred level of activity as quickly and safely as possible. The ability to achieve this goal must rely on utilizing progressive treatment phases that are delineated with specific goals and achievements.

Table 1. Pectoralis tendon repair guidelines

Type of Repair	Guidelines	Full AROM/PROM
Tendon – tendon	Sling 4 weeks	14-16 weeks
Bone – tendon	Sling 3 weeks	12-14 weeks

should not occur. To help decrease these physical symptoms, electrical stimulation and cryotherapy are recommended. Spear et al<sup>53</sup> has demonstrated that cryotherapy appears

### Immediate Post-operative Phase (0-2 weeks)

Goals for the immediate post-operative phase are 1) protect the healing tissue, 2) diminish post-operative pain and swelling, and 3) limit the effects of prolonged immobilization. Direct soft tissue repairs (tendon to tendon or muscle-tendon unit to tendon) require a slight rehabilitation delay to allow for adequate soft tissue healing before placing considerable stress to the repaired tissue. The immediate post-operative phase lasts for up to 3 weeks. In this time frame a gradual progression of passive range of motion (PROM) is began at 2 weeks. The patient is maintained in sling immobilization for 3 weeks. Passive ROM is taken to neutral external rotation and allowed to be increased by 5 degrees per week. Forward flexion is passively taken to 45 degrees increasing 5-10 degrees per week (Table 2). Passive ROM is performed to help soft tissue healing by increasing collagen synthesis and promoting correct alignment of fibers that are oriented parallel to the movement that is required to return full functional use of the upper extremity. No active range of motion (AROM) is allowed in the shoulder, but AROM is promoted for the rest of the upper extremity including elbow, forearm, and wrist/hand.

As with any surgical procedure, controlled trauma is part of the surgical process. Therefore, recognizing pain and localized edema is common. Since this surgical procedure is extracapsular, an actual joint effusion

to be an effective adjunct following shoulder surgical procedures. Interferential electrical stimulation or high volt galvanic stimulation can be used to assist in decreasing post-operative pain, soreness, and swelling.<sup>54,55</sup>

In this phase, PROM is performed by the clinician to decrease the risk or unwanted adhesion formation in and around the post-operative surgical site. Because this surgical procedure does not require entrance into the joint cavity, intra-articular adhesions are generally not one of post surgical sequelae. Of more concern with these procedures are extra-articular adhesion formation around the surgical incisions, which will create mobility problems. Additionally, an unsightly and unfavorable scar can be emotionally and socially devastating, especially to body-builders whose main desire is anatomical symmetry and cosmetic perfection. Once the incisions are healed and closed, gentle superficial scar tissue mobilization can be initiated. Scar mobilization should occur parallel to the superficial incision, progressing to running across the actual scar. Scar massage should be with enough pressure to blanch the scar.<sup>56</sup> Scar massage will be helpful to break

up collagen fibers, resulting in a softer, flatter, paler scar with better cosmesis,<sup>57</sup> in addition to promoting soft tissue mobility.<sup>58</sup>

Passive pendulum exercises are also encouraged as part of the home exercise program to increase mobility of the shoulder joint. Active assistive range of motion (AAROM) and gentle submaximal isometrics are began at 2-4 weeks post-operatively to begin stressing the contractile

Table 2. Range of Motion Guidelines

Week	ER @ 0° Shoulder Adduction	Forward Flexion	Abduction
2	0	45	30
3	5	50-55	35
4	10	55-65	40
5	15	60-75	45
6	20	65-85	50
7	25	70-95	55
8	30	75-105	60
9	35	80-115	65
10	40	85-125	70
11	45	90-135	75
12	50	95-145	80
ER = External rotation			

Table 3. Pectoralis Tendon Post-operative Protocol

<b>POST-OPERATIVE REHABILITATION FOLLOWING PECTORALIS TENDON REPAIR</b>	
<b><u>PHASE I – IMMEDIATE POST-OPERATIVE PHASE (WEEKS 0-2)</u></b>	
Goals	Protect healing repaired tissue Decrease pain and inflammation Establish limited range of motion (ROM)
Exercises	No exercise until end of 2 <sup>nd</sup> week
Sling	Sling immobilization for 2 weeks Passive rest for full 2 weeks Allow soft tissue healing to begin uninterrupted Allow acute inflammatory response to run normal course
<b><u>PHASE II – INTERMEDIATE POST-OPERATIVE PHASE (WEEKS 3-6)</u></b>	
Goals	Gradually increase ROM Promote healing of repaired tissue Retard muscular atrophy
Week 2	Sling immobilization until 3 <sup>rd</sup> week Begin passive ROM per guidelines (Table 2) External rotation to 0 beginning 2 <sup>nd</sup> week Increasing 5 degrees per week Forward flexion to 45 degrees Increasing 5-10 degrees per week
Week 3	Wean out of sling immobilizer – week 3 Continue passive ROM per guidelines (Table 2) Begin abduction to 30 degrees Increasing 5 degrees per week Begin gentle isometrics to shoulder/arm <u>EXCEPT</u> pectoralis major Scapular isometric exercises
End of Week 5	Gentle submaximal isometrics to shoulder, elbow, hand, and wrist Active scapular isotonic exercises Passive ROM per guidelines (Table 2) Flexion to 75 degrees Abuction to 35 degrees External rotation at 0 degrees of abduction to 15 degrees
<b><u>PHASE III – LATE POST-OPERATIVE PHASE (WEEKS 6-12)</u></b>	
Goals	Maintain full ROM Promote soft tissue healing Gradually increase muscle strength and endurance

Week 6

- Continue passive ROM to full
- Continue gentle sub maximal isometrics progressing to isotonic
- Begin sub maximal isometrics to pectoralis major in a shortened position progressing to neutral muscle tendon length.
- Avoid isometrics in full elongated position

Week 8

- Gradually increase muscle strength and endurance
- Upper body ergometer
- Progressive resistive exercises (isotonic machines)
- Theraband exercises
- PNF diagonal patterns with manual resistance
- May use techniques to alter incision thickening
- Scar mobilization techniques
- Ultrasound to soften scar tissue

Week 12

- Full shoulder ROM
  - Shoulder flexion to 180 degrees
  - Shoulder abduction to 180 degrees
  - Shoulder external rotation to 105 degrees
  - Shoulder internal rotation to 65 degrees
- Progress strengthening exercises
  - Isotonic exercises with dumbbells
  - Gentle 2-handed sub maximal plyometric drills
    - Chest pass
    - Side-to-side throws
    - BodyBlade
    - Flexbar
    - Total arm strengthening

#### **PHASE IV - ADVANCED STRENGTHENING PHASE (WEEKS 12-16+)**

Goals

- Full ROM and flexibility
- Increase muscle strength and power and endurance
- Gradually introduce sporting activities

Exercise

- Continue to progress functional activities of the entire upper extremity
- Avoid bench press motion with greater than 50% of prior 1 repetition max (RM)
- Gradually work up to 50% of 1 RM over next month.
- Stay at 50% prior 1 RM until 6 months post-operative, then progress to full slowly after 6 month time frame

KEYS

- Don't rush ROM
- Don't rush strengthening
- Normalize arthrokinematics
- Utilize total arm strengthening

properties of the repaired tissue and surrounding musculature which helps retard muscle atrophy and loss of muscle control. To maintain cardiovascular condition the athlete should continue with prior aerobic training on recumbent or standard exercise cycle, but is asked not to perform aerobic exercises such as elliptical runners, cross-country machines, or running/jogging on treadmills to decrease risk of injury in case of accidental loss of balance (Table 3).

### **Intermediate Post-operative Phase (3-6 weeks)**

This phase is a short 3 week phase in which PROM is slowly advanced. Goals in the Intermediate Post-operative Phase include 1) Continued progression of ROM, 2) enhance neuromuscular control, and 3) increase muscular strength. Prior ROM is advanced per earlier discussion, while shoulder abduction is began at 30 degrees increasing 5 degrees per week, with abduction and external rotation performed last. Toward the end of this phase AAROM is began and patient's performance of PROM is allowed. Because in this phase soft tissue healing should already be initiated, patient AAROM is started. Range of motion of the shoulder can be performed with a cane or L-bar into gentle flexion, scaption, and external rotation. Patient education regarding ROM limitations that still exist are imperative for safe return of full mobility without re-rupture, stretching, or loosening of repaired soft tissue. No AROM is allowed early in this phase, while gentle limited AROM is allowed toward the end of this phase. Painful elevation or active mobility of the shoulder is detrimental to the healing soft tissue and, therefore, should not be allowed.

Gentle sub-maximal isometrics are performed for the rotator cuff muscles at this time to enhance dynamic shoulder stability. Known as "rhythmic stabilization" exercises, these isometric exercises are performed with the patient lying supine with the arm in the balance position of 90 degrees of flexion. The athlete is asked to maintain a position of full elbow extension while the arm is in 90 degrees of flexion while the clinician applies small joint perturbations in various directions. These exercises are performed in a manner initially in which the athlete can view and prepare for the contraction needed to keep the arm stable in a proactive manner, known as proactive training. This stabilization can be progressed to performing these perturbations in randomized patterns followed by increasing speed in which perturbations are made. These exercises can further be progressed from eyes open to eyes closed pattern, which is known as reactive train-

ing.<sup>60</sup> Performance of these stabilization exercises with eyes closed is done to enhance reactive muscle performance. These exercises are generally performed in multiple angles at approximately 20 degree intervals through a safe range of motion. The isometrics are performed in this fashion because of a 20 degree range of motion physiological overflow found with isometric exercises.<sup>59</sup>

In this phase, exercises for the scapula can be initiated. Scapular "setting" exercises are performed with the scapula in a retracted position to enhance postural control. Early in the intermediate phase, internal shoulder rotation and shoulder flexion isometrics are not performed to decrease risk of excessive activation of the pectoralis major muscle contractions during those movements. Toward the end of this phase (5-6 weeks), gentle sub-maximal isometrics with the pectoralis major in a shortened position can begin and carried into the next phase. Judicious use of extension, abduction, and external rotation isometrics are performed. It should be cautioned that during this early time frame that exercises such as "rhythmic stabilization" are performed initially at very low levels, reaching forces of 2-4 pounds at most.

Additionally scapulothoracic isometrics and AROM exercises are used during this time frame. Davies and Ellenbecker<sup>60</sup> have described total arm strengthening that can have a positive effect on the entire upper extremity. These exercises should be initiated early to ensure adequate strength of other remaining upper extremity musculature.

### **Late Strengthening Phase (6-12 weeks)**

The advanced strengthening phase begins at around 6 weeks and extends to around 16 weeks. Goals to be obtained at this time include achieving and maintaining full shoulder mobility both actively and passively, and gradually increasing muscular strength and endurance. Davies<sup>59</sup> has described an exercise progression continuum as a means of integrating a safe and systematic process of progressing patients through an exercise program. Therapeutic exercises in this phase should begin with gentle submaximal isometrics for the pectoralis. These exercises should initially be performed with the shoulder adducted to place the pectoralis in a relatively shortened position. This activity should not be performed in full horizontal adduction as the pectoralis would be placed in a position nearing active insufficiency. Isometric exercises should be progressed to neutral shoulder or the



“balance position” (Figure 7) and toward the end of this phase performed in a more lengthened position. Rarely should these isometric exercises be performed in full horizontal abduction with the pectoralis muscle in a fully lengthened position, which may place excessive strain on the repaired tissue.

Usually by the 12 week period gentle isotonic tubing exercises can be started in a safe ROM that does not place excessive stretch on the repair site. At the end of this phase proprioceptive neuromuscular facilitation (PNF) techniques can be helpful by simultaneously recruiting all the muscles in the upper extremity by incorporating both spiral and diagonal patterns of motion.<sup>61</sup> In the overhead athletes, the PNF patterns of diagonal 2 (D2) flexion and extension movements are performed because these patterns are very similar to overhead throwing patterns. Initially, the PNF patterns should be concentric against gentle manual resistance. Following tolerance of manual techniques, PNF can be performed using exercise tubing. Progressive resistance can be increased by using tubing for eccentric control.

Full AROM exercises can be performed at this time. Careful emphasis should be placed on normalizing glenohumeral arthrokinematics to allow unrestricted mobility. Due to prolonged immobilization with this surgical procedure some arthrokinematic limitations are common that need to be addressed. Arthrokinematic issues that commonly remain include a decrease in anterior, inferior, and posterior glide passive motions of the glenohumeral joint. Joint mobilizations for these restrictions should be initiated (Figure 8). Additionally, arthrokinematic limitations of the sternoclavicular and acromioclavicular should be assessed with appropriate interventions, as needed.

Because the scapulothoracic joint is not a true synovial joint, rarely does this pseudo-joint incur motion prob-



Figure 7. Isometrics for the shoulder in the “balance position.”



Figure 8. Joint mobilization to address inferior capsule contracture limiting normalization of glenohumeral joint arthrokinematics.

lems. Motion restrictions of the scapulothoracic joint can result from excessive use and compensation of the posterior scapular muscles. Commonly during this time the patient may exhibit a compensatory “shrug sign,” also known as scapular “hiking” or a reverse scapulohumeral rhythm in which the scapula moves more than the humerus.<sup>62</sup> When initiating shoulder elevation movements, if the entire shoulder girdle or scapula elevates, a faulty neuromuscular pattern is occurring. In this form of compensation the weaker rotator cuff muscles are being overpowered by the stronger deltoid muscles. If this pattern of movement occurs, it should be stopped and addressed immediately. Continuation of this faulty pattern will only prolong its use and potentially set the patient up for rotator cuff impingement problems and possible rotator cuff tear. If these compensations are occurring, the patient should limit AROM in shoulder elevation to below 90 degrees and begin dynamic stabilization drills for the scapular and rotator cuff muscles.

### Advanced Strengthening Phase (12-16+ weeks)

The final phase of the post-operative program following pectoralis tendon repair is the Return to Activity Phase and occurs after 12-16+ weeks. The goals for this period include full AROM/PROM of the shoulder and a gradual return of full strength for resumption of all prior activities of vocation or daily living. Treatment at this stage can begin to be more aggressive, simply meaning, weight can be increased and multi planar exercises can be begun. If shoulder ROM is full, light overhead activities can be progressed. These activities can include gentle advanced activities that employ concentric/eccentric contractions such as plyometric activities with plyoball catches or use of the BodyBlade (Figure 9). For the weightlifter or bodybuilder a slow progression of light shoulder press and bench press can now be performed. No lifting greater than 50% of the athlete's previous 1 repetition maximum should be performed

until 6 months after surgery. Additionally, the use of heavy weighted pec dec and flys should be avoided for up to 6 months after surgery due to abnormally large amounts of stress to the pectoralis major. A pec dec refers to the seated pectoralis exercise machine in which the arms/elbows of the participant are placed around pads bilaterally and the participant horizontally flexes or adducts the shoulders toward each other. The fly is a similar movement done with dumb bells in each hand on a flat or incline bench. When performing these exercises it may be wise to slightly alter the lift allowing maintenance of the humerus in a position anterior to the frontal plane, which drastically reduces the amount of strain on the pectoralis major muscle and tendon.



Figure 9. BodyBlade.

### Surgical Outcomes

Reviewing 16 repairs, Kretzler and Richardson<sup>24</sup> reported full strength return in 13 cases. Two of the three who did not have full strength presented for testing more than 5 years after the repair. Despite this delay, and the fact that full strength was not attained, all three experienced significant improvements in their pre-surgery strength. All 16 had a return of normal pectoralis contour and relief of pain.

Schepsis et al<sup>63</sup> assessed surgical outcomes following 13 patients undergoing pectoralis major repair. Surgical patients were broken into acute and chronic repairs, both of which fared significantly better with subjective reports of function rated at 96% and 93%, respectively, compared to 51% in a group of non-operative treated patients. Isokinetic strength was greatest in the acute group (102%) of the opposite side, compared to 94% with the chronic group, while non-operative patients only achieved 71% of the contralateral upper extremities strength.

Zeman and colleagues<sup>19</sup> reported on nine athletes that sustained pectoralis major tears. Five of their patients were treated conservatively and obtained good results in that they were able to achieve normal ROM, with only mild pain and weakness. Four of the patients were treated surgically and obtained excellent results which were described as normal ROM and excellent strength.

McEntire and colleagues<sup>20</sup> reported on 11 cases of

pectoralis rupture and noted that the muscle belly injuries do well when treated non-operatively, as long as there is not a large hematoma or infection. Finally, Wolfe and colleagues<sup>7</sup> reported superior results with surgical repair vs conservative treated patients. Their surgically treated group had peak torque and low-speed work values of 105.8% and 109.0% that of the uninvolved side, respectively, compared with 74.0% and 60.1% which was that of the conservatively treated group.

Bak and colleagues<sup>8</sup> performed a meta-analysis of 112 cases of pectoralis major rupture and found that excellent or good results were reported for 88% of surgically treated cases versus 27% of those treated conservatively. These authors concluded that with rare exceptions, no indication for nonsurgical treatment of pectoralis tendon ruptures was indicated.

In a more recent meta-analysis, Aarimaa and colleagues<sup>3</sup> analyzed final outcomes following surgical repair of the pectoralis major using 33 patients with operative treated pectoralis major rupture patients of their own and combined these with a meta-analysis of previously reported cases in the literature. The authors found that both their cases and those from the literature demonstrated that early operative treatment is associated with better outcome than delayed treatment, while delayed treatment had better outcomes than non-surgical treatment.

### Return to Play Guidelines

The return to play criteria presented in this manuscript is somewhat dependent upon the activity that the athlete plans to continue. Although a cookbook approach should not be used for return to play criteria, several commonalities do exist. To begin with, the athlete's willingness to return to play both physically and mentally is very important. Because a gradual progressive rehabilitation program has been utilized, a general idea of the athlete's physical capabilities is well known. In general, to be released from the physician the athlete must have a satisfactory clinical exam which consists of pain-free full, or adequate ROM, and normal strength. When available, isokinetic testing can be utilized to gain a more objective measure of muscle strength. As mentioned previously, for the weightlifter or bodybuilder a slow progression of weight training should be followed. A strong recommen-

dation is that no lifting greater than 50% of the athlete's previous 1 repetition maximum be performed until 6 months post-operative. Additionally, the use of heavy weighted pec dec and flys should be avoided for up to 6 months due to abnormally large amounts of stress to the pectoralis major.

## SUMMARY

Early recognition and surgical treatment of a ruptured pectoralis major tendon followed by a graded post surgical rehabilitation program that incrementally increases ROM and stress to the repaired tendon allows a full return of functional strength and mobility. This manuscript outlines a graduated post-operative protocol for return following pectoralis major tendon repair.

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